Information Geometry and its Applications to Computer Vision and Medical Image Analysis*

Baba .C. Vemuri
Professor & Director, Laboratory for Computer Vision & Graphics and Medical Imaging
Department of Computer & Information Science & Engineering
University of Florida, Gainesville, Florida

Abstract

Information Geometry is an amalgam of Information theory and the theory of smooth manifolds. It allows one to ask questions about statistics of data that live on manifolds. As data acquisition mechanisms become more advanced over time, there is a need for more sophisticated analysis tools. Specifically, matrix-valued data analysis has gained popularity over the past decade in the fields of Computer Vision and Medical Image Analysis. In Computer Vision, features such as covariance matrices are common to many application domains such as tracking, texture analysis etc. In Medical Image Analysis, diffusion tensor imaging has gained a lot of traction in the recent past. The common thread between these two disparate applications is that the data (derived or acquired) are matrix-valued, specifically involving symmetric positive definite (SPD) matrices. In this talk, I will present novel methods to process these data sets. In the first part of this talk, I will present a novel probabilistic dynamic model on the space of SPD atrices (P_n) – based on Riemannian geometry and probability theory – in conjunction with a intrinsic recursive filter for tracking a time sequence of SPD matrix measurements in a Bayesian framework. This newly developed filtering method is used for the covariance descriptor updating problem in covariance tracking, leading to a new and efficient video tracking algorithm. I will present synthetic and real data examples of video tracking along with comparisons to state-of-the-art techniques.

In the second part of the talk, I will present a novel Bregman divergence called total Bregman divergence (tBD) that is statistically robust and yields a closed form solution to the problem of computing the L_1 norm center of a population of SPD matrices. As an application of its use, I will present a technique for the peice-wise smooth segmentation of diffusion weighted MRI (DW-MRI) data sets approximated by fields of SPD matrices. DW-MRI is a non-invasive imaging technique that allows the measurement of directionally dependent water molecular diffusion through tissue *in vivo*. The directional dependence of water diffusion allows one to infer the axonal connectivity patterns prevalent in tissue and possibly track changes in this connectivity over time for various clinical applications.

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